# Solving the Challenge Problems Using Expert Knowledge Theory & Methods

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# Challenge Problems Vs. Reality

- Challenge problems are too well defined relative to complex physical problems.
- Experts should be able to determine the response form (e.g., intervals) according to their knowledge, thinking, and problem solving.
- Experts may have knowledge about relative likelihoods of values within interval estimates.
- Sources of uncertainties are limited here (e.g., no extrapolation).
- Numerical interval answers are assumed; often initial expert estimates are linguistic.
- Problems are constrained with fixed assumptions.

# Elicitation Principles

- Utilize terms and methods from the way experts think, work and problem solve.
- Provide constant feedback to experts (especially for expert resolution).
- Use bias minimization techniques.
- Use verbal protocol and verbal probe (get experts to think aloud and use the terms and work within the culture).
- Use the decomposition principle: experts learn more and solve problems better if the problem is broken down into finer details.
- Remember all information is conditional and some of these conditions relate to how expert solve problems and the level of detail (resolution or granularity) they think.
- Pilot test questions.
- Document assumptions, cues, heuristics, problem solving.
- Establish the uncertainty and analysis reference or standard as early as possible.

# Cognitive Biases

**Bias:** A skewing from a standard or reference point (reality).

**Anchoring** Experts cannot move from preconceptions.

**Inconsistency** Confusion, e.g. differing assumptions or definitions, can lead to inconsistency. Memory problems and fatigue also contribute.

**Underestimation of Uncertainty** We often think we know more than we really do.
[Classic (and deadly) example is the Titanic].

**Availability** Depending upon personal experience, experts cannot accurately account for rare events.

# Motivational Biases

**Bias:** Degrade the quality of elicited knowledge.

**Group Think** Group social pressure to slant responses or silently acquiesce to what they believe will be acceptable to the group.
[Classic (and deadly) example is the Bay of Pigs].

**Misinterpretation** Inadequate translation of knowledge into response.

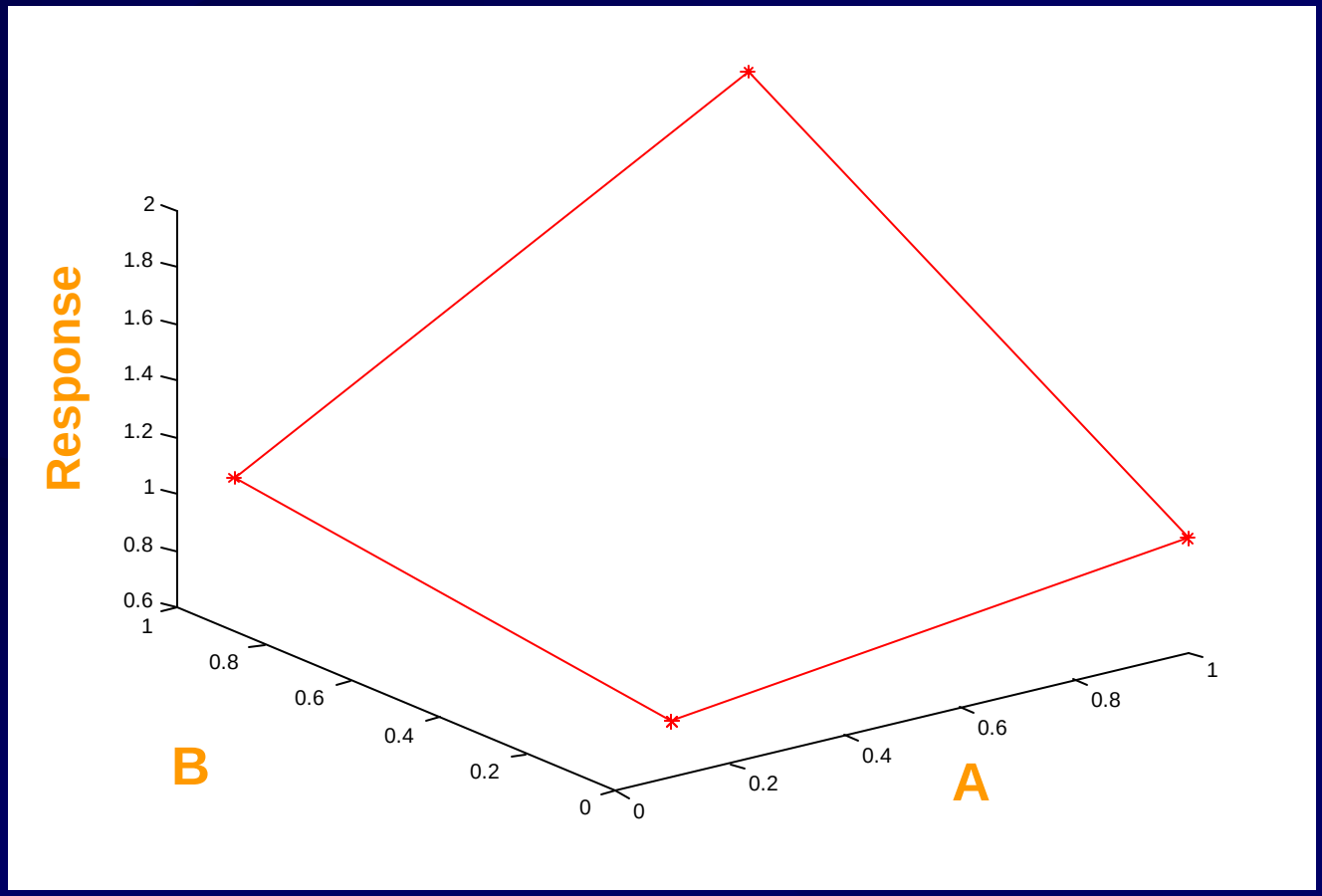
**Wishful Thinking** Experts' hopes influence their judgment.

**Impression Management** Responding according to politically correct interpretations.

# Problem 1:
# Single Expert Elicitation

- Elicit ranges for parameters A & B.
- Display resulting responses for review
- Probe expert's reasoned reactions
- Modifications:
  - -Parameter values only
  - -Responses only (if inverse is possible)
  - -Both (iterative)

# An Expert's Elicitation of Estimates: Problem 1 Initial Estimate

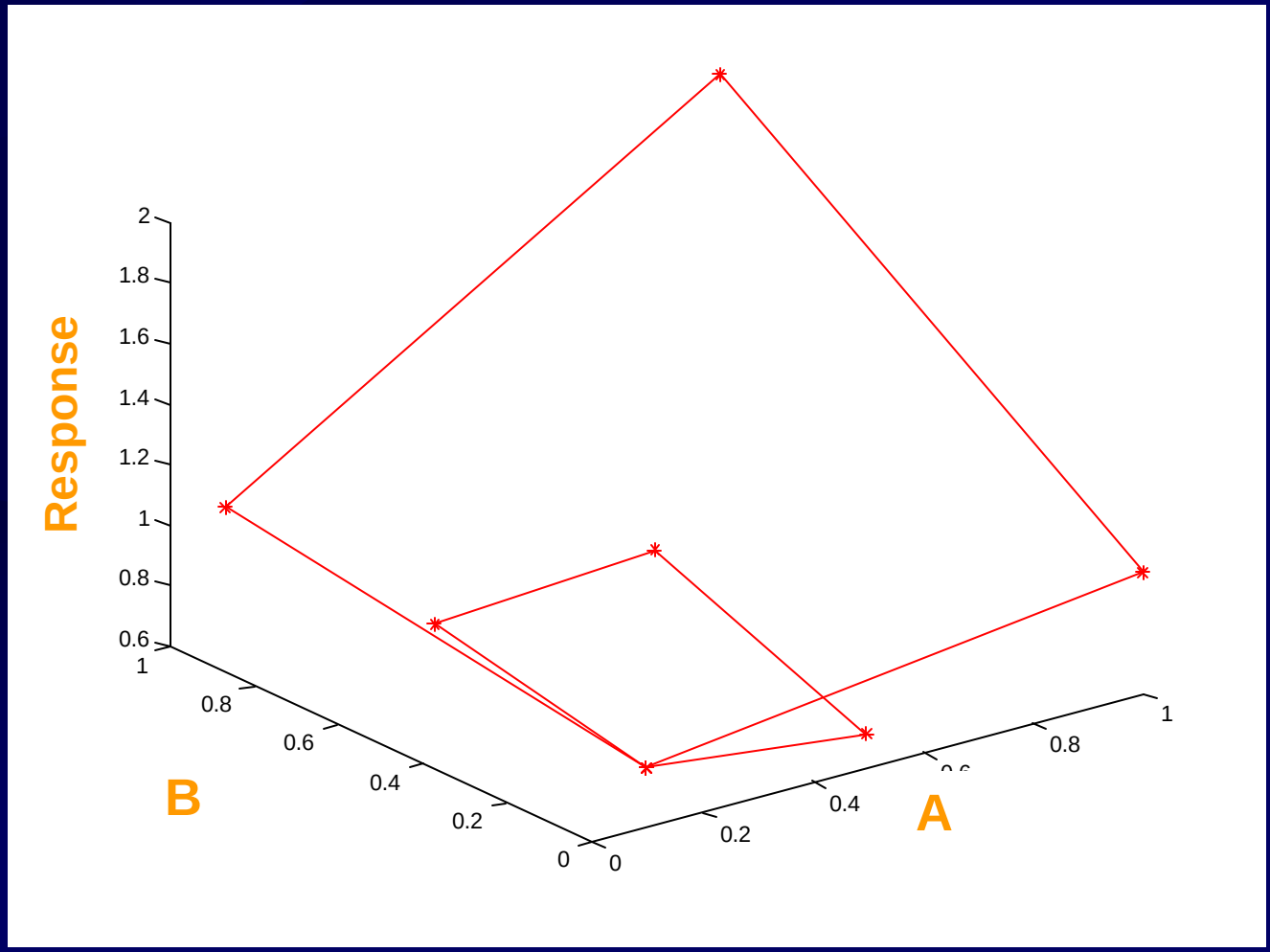


# Sources of Expert Disagreement: A True Example (Mirrors 3c)

- Individual elicitation with experts results in broad disagreement; categorized by level of experience (seniors versus novices).
- Responses (minus identifiers) discussed with all experts.
- Hypothesis: Level of experience will explain
  - New elicitation tested hypothesis with problem-solving exercise and verbal report
- Conclusion: Novices used different sources of information, drew on less information, and made different assumptions than seniors.

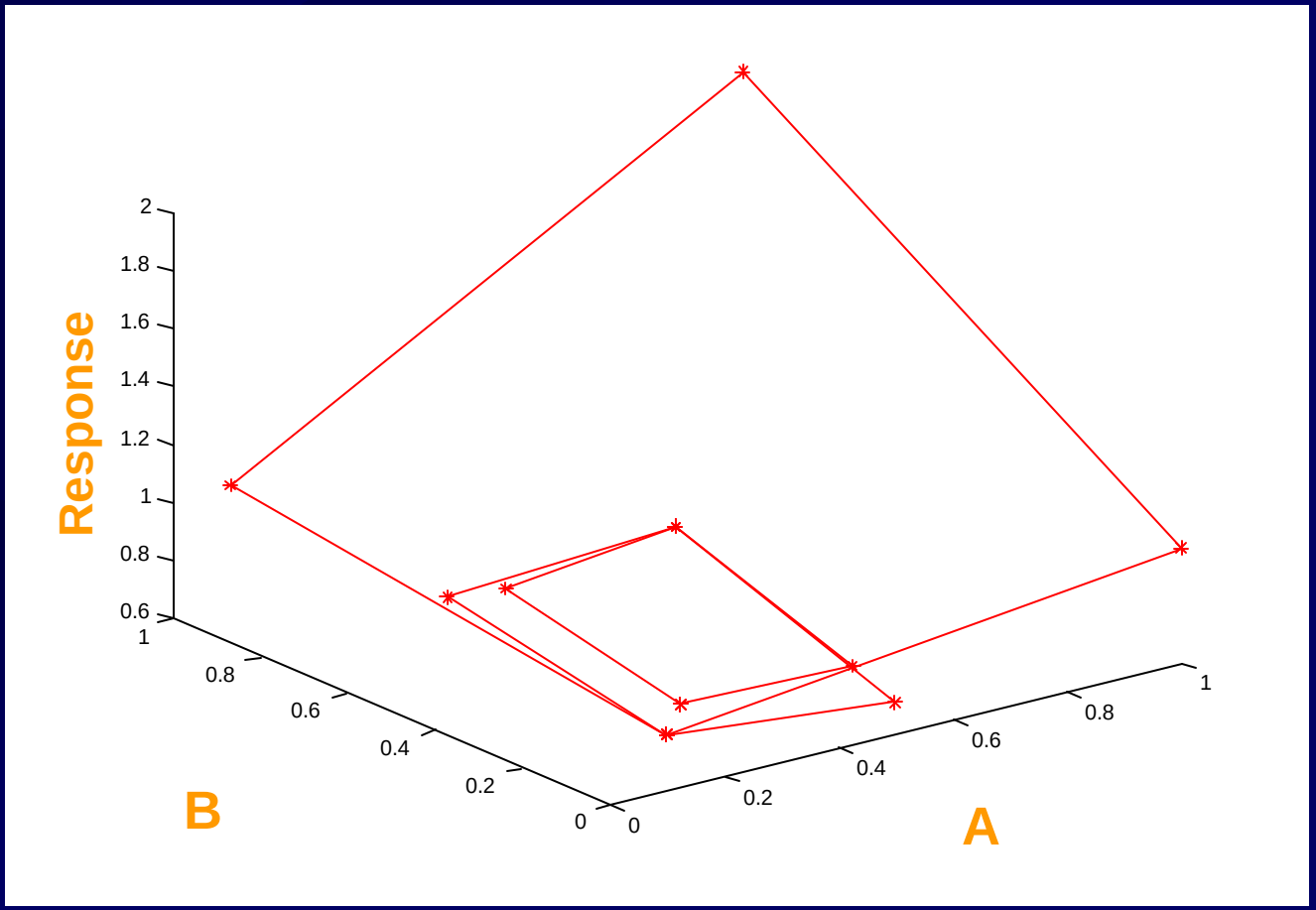
# An Expert's Elicitation of Estimates: Problem 1 Initial + Iteration 1

**Expert cuts initial estimates in half.**



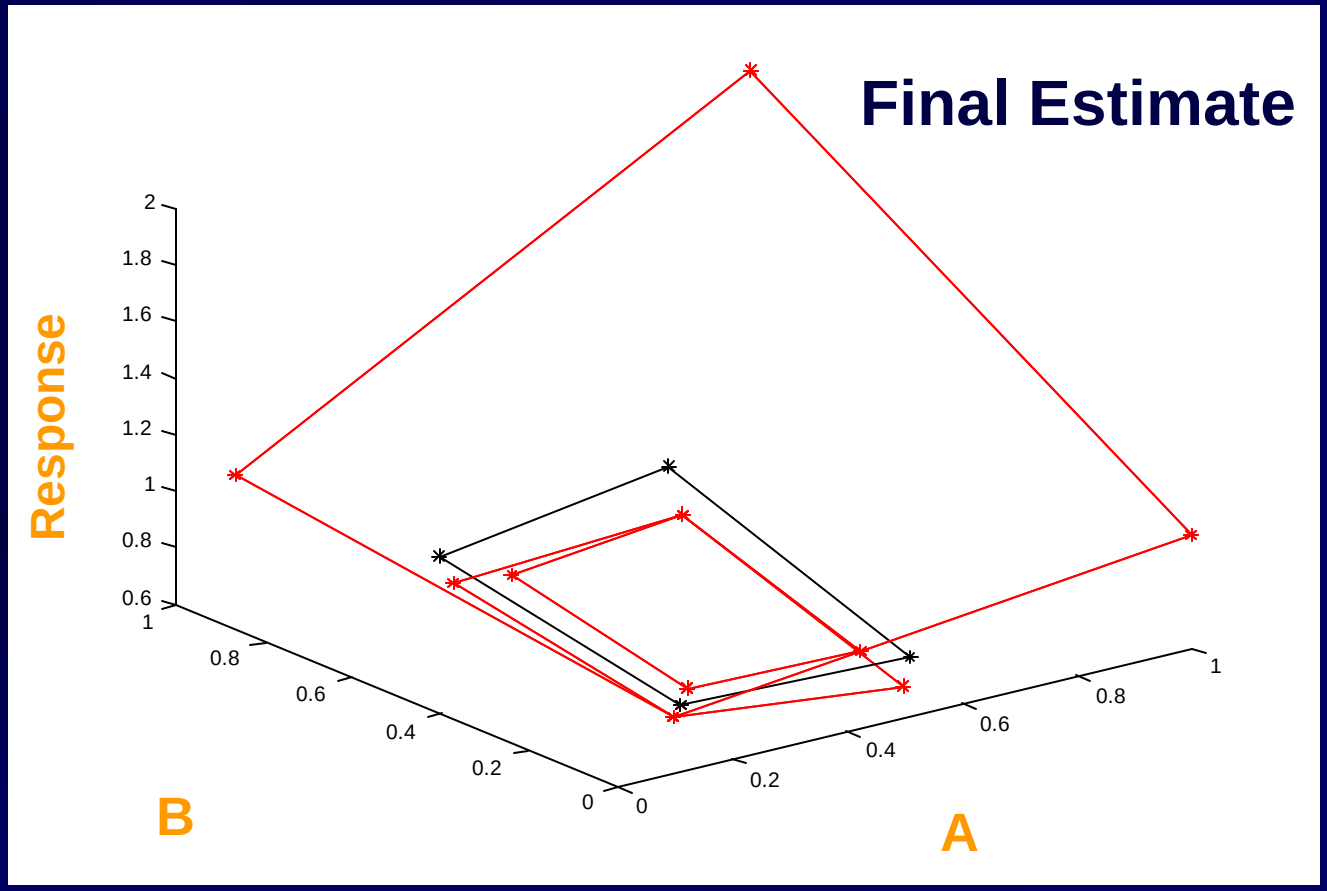
# An Expert's Elicitation of Estimates: Problem 1 Initial + Iterations 1 & 2

**Expert adjusts lower bounds.**



# An Expert's Elicitation of Estimates: Problem 1 Final Iteration

**Expert expands uncertainty.**



# Problem 3c: Multiple Expert Elicitation

**For each expert:**

- **Elicit ranges for parameters A & B.**
- **Display resulting responses for review**
- **Probe expert's reasoned reactions**
- **Make modifications**

# Uncertainty in Multiple Expert Resolution

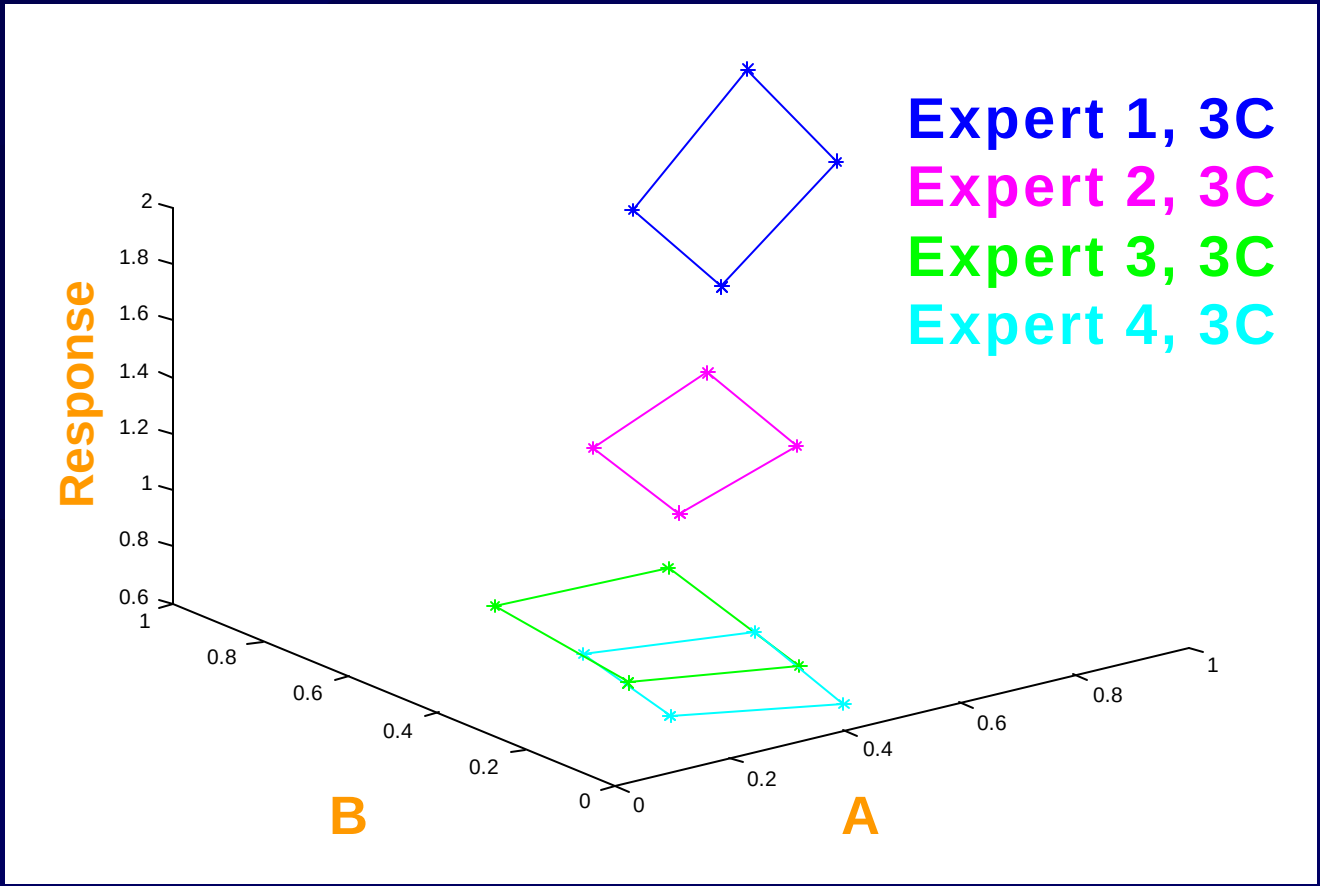
**Non overlapping results indicate unresolved expert differences AND/OR reflect the true (current) state of the unknown (epistemic uncertainty).**

**Resolution of differences or reduction in uncertainty requires additional information.**

# Problem 3c: Multiple Expert Resolution

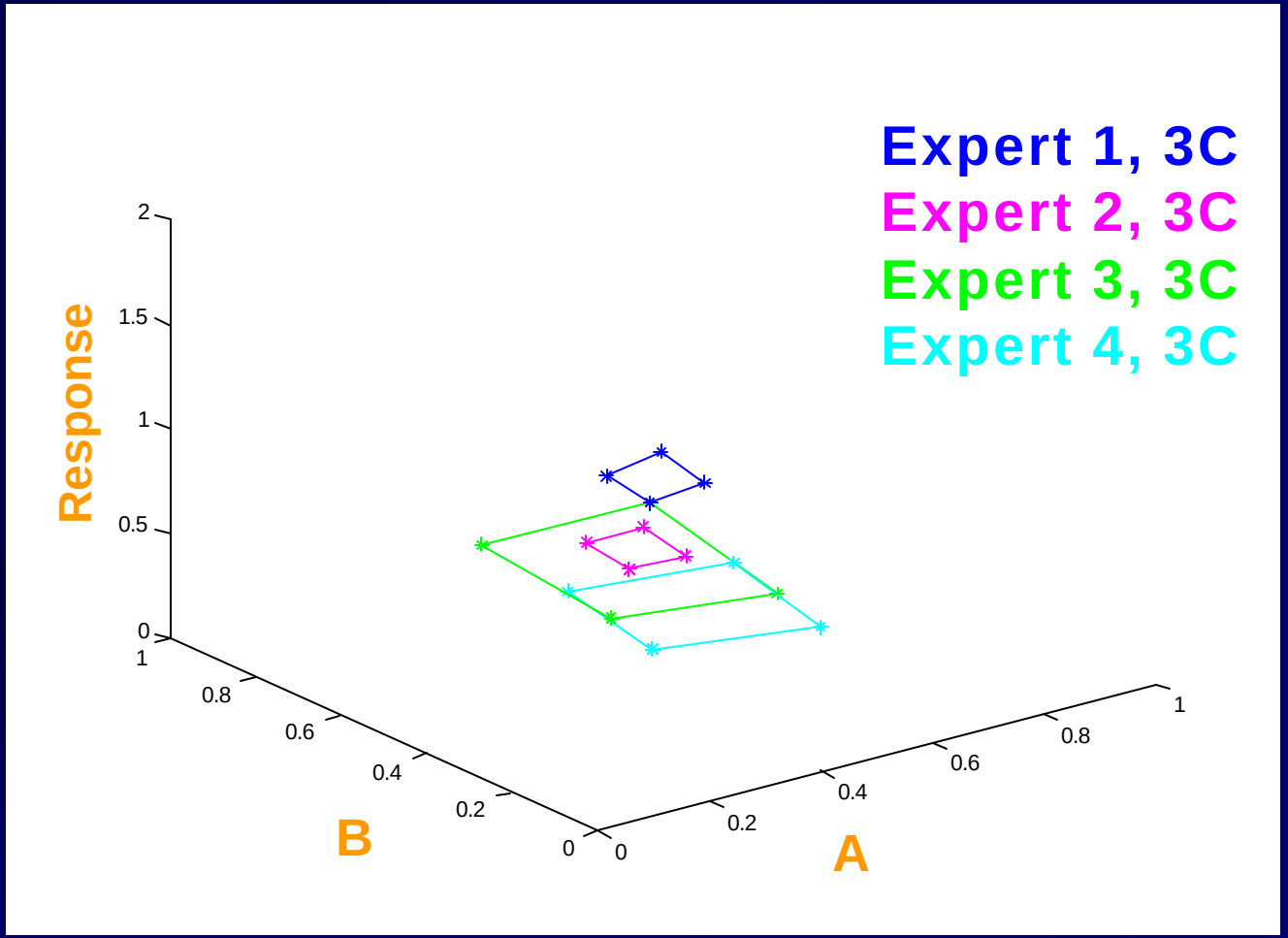
- Analyst examines multiple expert results
- For each expert, probe on differences
  - -Solving the same problem?
  - -Differing assumptions?
  - -Differing conditions?
  - -Underestimation of uncertainty?
- Analyst examines new results
- Experts examine all results
  - -Reach consensus together OR
  - -Make individual adjustments

# Four Experts' Elicitation of Estimates: Problem 3c Initial Estimate



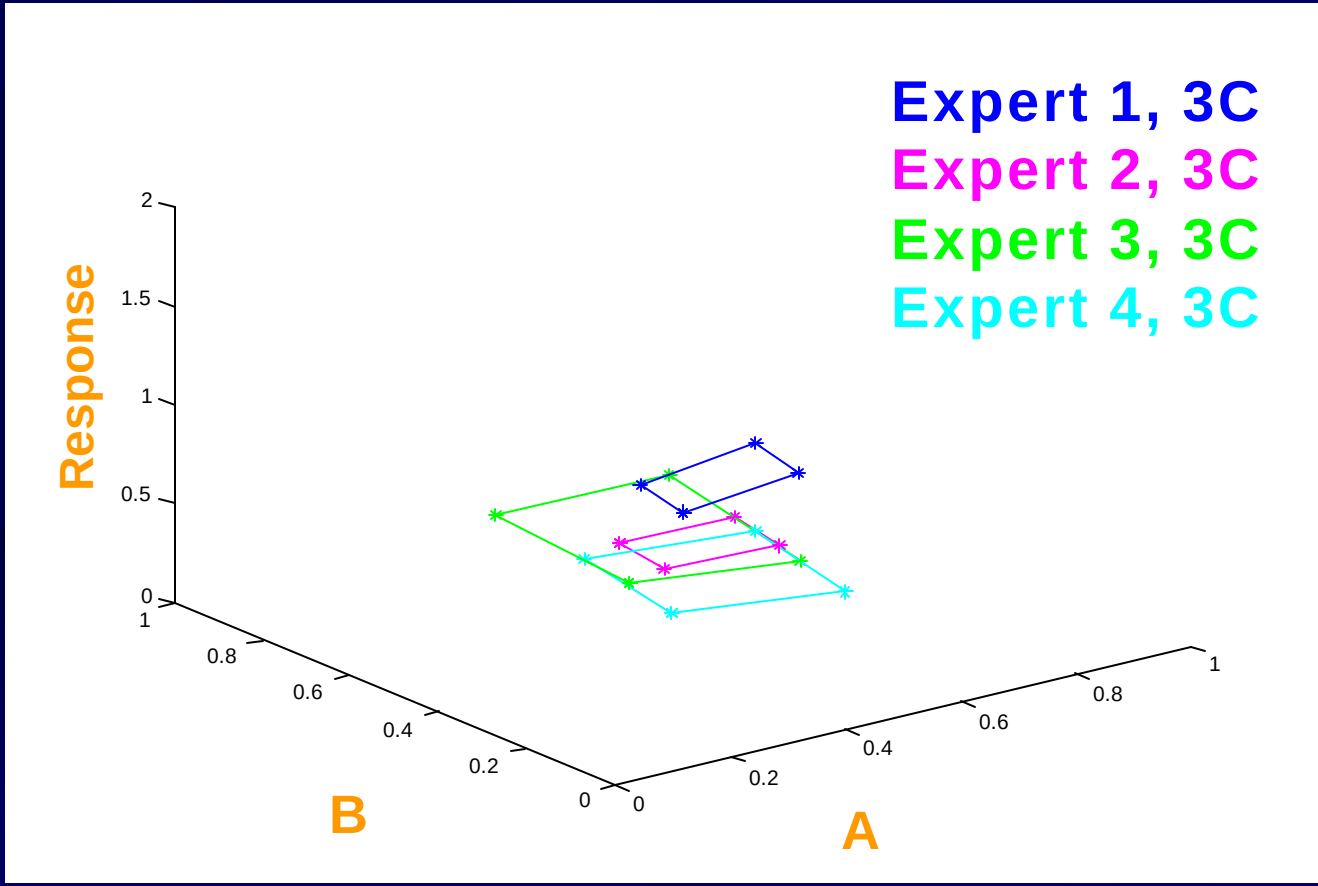
# Four Experts' Elicitation of Estimates: Problem 3c Initial + Iteration 1

**Novices (1 & 2) cut estimates in half based upon shared additional information from seniors.**



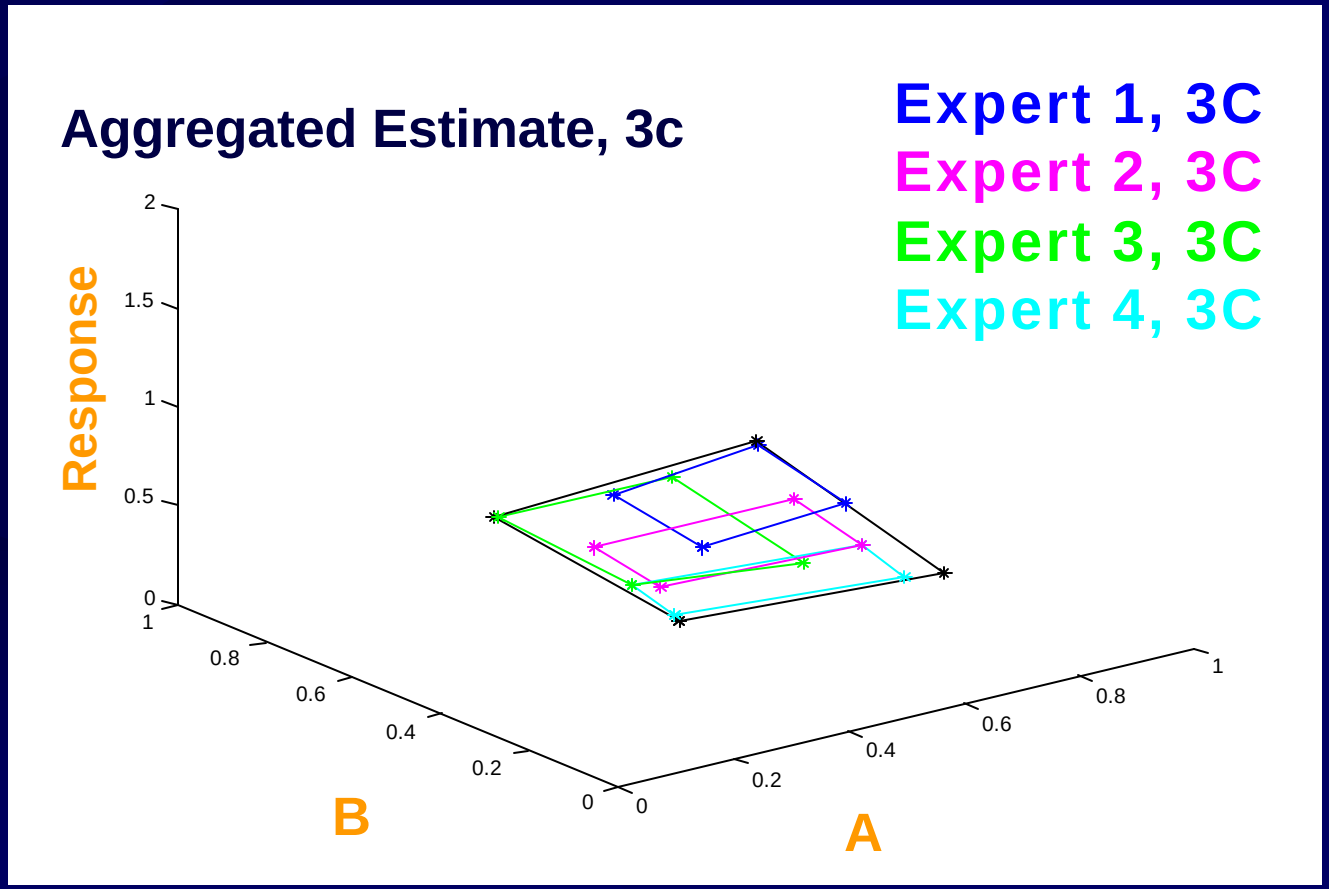
# Four Experts' Elicitation of Estimates: Problem 3c Initial + Iterations 1 & 2

Novices (1 & 2) expand and shift estimates based upon shared problem solving information from seniors.



# Four Experts' Elicitation of Estimates: Problem 3c Final Iteration

Novices (1 & 2) and senior (4) expand estimates based upon shared aging assumption information from senior (3).



# They Just Don’t Agree

**DOCUMENT, DOCUMENT, DOCUMENT**
**expert reasoning to determine aleatory vs. epistemic uncertainty**

**Are Experts…**

- **Drawing on different information/data?**
- **Missing information?**
- **Not solving the same problem?**
- **More/less experienced with problem?**
- **Working in an emergent area of knowledge?**

**Elicitation**

- **Identify potential cognitive bases for disagreement**
- **Redesign, re-administer elicitation**
- **Disagreement may not be resolvable because wide uncertainty REALLY exists.**

# Elicitation for Resolution

- Use evidence to develop new elicitation
- From Example: Modified Delphi could work
    - Share responses anonymously among participants to ensure that all consider same information
- Group elicitation
  - Prone to groupthink bias
- Individual interview: Challenge
  - “Borrow” respondents evidence to probe reasoning during interview

# Combining Multiple Experts Estimates

- Expert supplied weights
  - -Each expert rates others
  - -Self weights
- Analyst supplied weights
  - -Maximum entropy solution
  - -Other information
- Decision maker supplied weights
  - -Maximum entropy solution
  - -Other information

# References


J.M. Booker, T.R. Bement, M.A. Meyer, W.J. Kerscher, III "PREDICT: A New Approach to Product Development and Lifetime Assessment Using Information Integration Technology, " to appear in *Handbook of Statistics: Statistics in Industry* (Rao and Khattree, editors), 2002.

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